Spatial distribution of helium isotopes in Icelandic geothermal fluids and volcanic materials

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We have undertaken a detailed study of the distribution of helium isotope ratios ($^3He/^4He$) in Icelandic geothermal fluids, volcanic glasses and phyric lavas [1]. Along with presenting a new helium isotope dataset using phyric lavas largely from off-rift regions, we compiled published data and constructed a database of all available helium isotope data from Iceland. The new dataset reveals an exceptionally high $^3He/^4He$ from a phyric lava in NW-Iceland (47.5 R_A), which is among the highest values measured in any mantle-derived magma to date.

Modifications of primary (i.e., mantle-derived) helium isotope ratios, due to additions of air-derived helium and He from radiogenic ingrowth, were evaluated and the database was filtered accordingly. The geographical information system ArcGIS (ESRI) was used to perform spatial analysis on the filtered database and the interpolation method, Natural Neighbor, was used to calculate representative helium isotope ratios for all parts of Iceland, including off-rift regions.

The results show that helium isotope ratios for the whole of Iceland vary from 5.1 to 47.5 R_A. However, this study allows for a fine-scale distinction to be made between individual rift segments and off-rift regions. The results clearly reveal that each rift zone has its own distinctive mean isotope signature: 12–17 R_A in the Western Rift Zone, 8–11 R_A in the Northern Rift Zone and 18–21 R_A in the Eastern Rift Zone. Our isoscape map places new constraints on a previously inferred high-helium plateau region in central Iceland. Its location coincides with many geological features, e.g., eruption rates, location of abandoned rift segments, seismic velocity and gravity anomalies. Such high helium isotope ratios have been associated with undegassed and primordial mantle sources that have been isolated in the lower mantle over Earth's history. Thus, high-helium domains throughout Iceland are interpreted to mark the loci of present and past plume conduits, which help explain the considerable spatial variation in the sampling of a primordial mantle He component beneath the Iceland hotspot.

[1] Harðardóttir *et al.,* (2018), *Chemical Geology* **480,** 12-27.